

REMARKS

In response to the Official Action mailed on February 17, 2009, the application has been amended. No new matter has been added. Reconsideration of the rejections of the claims is respectfully requested in view of the above amendments and the following remarks.

Examiners Gamino and Ward are thanked for granting an interview to discuss the present application on June 2, 2009. At the interview, the differences between the methods described by the claims of the present application and methods used in the past to operate a solder bath were discussed.

In paragraph 1 of the Official Action, claim 24 was objected to on account of the language "the concentration being such that". The Applicants respectfully submit that "being such that" is grammatically correct and idiomatic, since "is such that" is a common English expression, and "being" is simply the present participle of "is". Therefore, "being such that" should be readily comprehensible to a speaker of English, and a person skilled in the art would have no difficulty in understanding the syntax and scope of this claim. However, in order to expedite prosecution, the Applicants propose to change "the concentration being such that" to "the concentration having a value such that" so as to avoid the language "being such that" and thereby

overcome the objection.

In paragraph 3 of the Official Action, claims 9, 10, 12, 14 - 16, and 20 were rejected under 35 USC 102(b) as anticipated by the description on pages 1 - 4 of the specification of previously conceived methods of replenishing a solder bath. This rejection is respectfully traversed.

The Official Action refers to the description on pages 1 - 4 as being the applicant's admitted prior art (AAPA). Since not every portion of that description is prior art or even admitted to be prior art, the description on pages 1 - 4 of the specification will simply be referred to as "the description on pages 1 - 4 of the specification" without any acknowledgement concerning whether anything on these pages is prior art.

Claim 9 describes a soldering method including replenishing a solder bath with a replenishment solder alloy having a higher concentration of the oxidation suppressing element than does the initial composition of the solder bath. Claim 9 has been amended to clarify that the initial composition of the solder bath refers to the composition prior to initial soldering using the solder bath. At the interview, it was agreed that this definition adequately defines the point in time at which the initial concentration is determined, and that this "initial composition" is distinguishable from the composition of a solder bath after a solder bath has been operating for some length of time or other possible situations described on page 3 of the Official Action,

which were not intended to be encompassed by the term "initial composition".

The description on pages 1 - 4 of the specification does not contain any description of replenishing a solder bath with a replenishment solder alloy having a higher concentration of an oxidation suppressing element than the initial composition of the bath, as set forth in claim 9.

As previously set forth in the amendment filed on December 4, 2008, page 3, lines 6 - 12 of the specification of the present application refer to Japanese Published Unexamined Patent Application Sho 54-84817, which discloses a deoxidizing alloy having a much higher content of P than is present in a solder bath. The deoxidizing alloy is added to the solder bath in small quantities solely to adjust the P concentration and is totally separate from a replenishment solder alloy used to maintain the level of the bath.

Page 3, lines 13 - 16 of the specification describe two known alloys containing P, but neither of these alloys is related to replenishment of a solder bath.

Page 3, lines 21 - 28 of the specification describe soldering using a P-free solder alloy in which a small amount of a solder alloy having a high concentration of P was charged into a solder bath as the P in the solder in the solder bath decreased, and a solder alloy not containing any P was supplied as the level of solder in the solder bath decreased. Thus, the

replenishment solder alloy was a solder alloy not containing any P, and the P-containing solder was not a replenishment solder alloy but an alloy for adjusting the P content of the bath.

Page 4, lines 1 - 7 of the specification describe a situation in which a solder bath is replenished with a solder alloy which is the same as the initial solder used to form the bath. As such, the replenishment solder alloy has the same concentration of an oxidation suppressing element as the initial composition of the bath.

Page 4, lines 11 - 17 describe a method in which a mother alloy which is adjusted to have a high concentration of an oxidation suppressing element is supplied to a solder bath periodically, such as every day or 2 - 4 times per month. This mother alloy is an alloy for adjusting the concentration of the oxidation suppressing element and not a replenishment solder alloy, since a solder bath needs to be replenished constantly to maintain the bath height and cannot possibly be replenished only "every day or 2 - 4 times per month".

Accordingly, none of the methods described on pages 1 - 4 of the specification of the present application is a method including replenishing a solder bath with a replenishment solder alloy having a higher concentration of an oxidation suppressing element than does the initial composition of the solder bath, as set forth in claim 9. Thus, those methods do not include all the steps set forth in claim 9 and so cannot anticipate it or claims 10, 12, and 16 which depend from claim 9. These claims are

therefore allowable. Dependent claims 14, 15, and 20 are likewise allowable, but they have been cancelled as unnecessary, so the rejection of these claims is now moot.

In paragraph 5 of the Official Action, "Claims" were rejected under 35 USC 103(a) as unpatentable over the description on pages 1 - 4 of the specification. Since pages 4 - 8 of the Official Action specifically mention claims 9, 10, 12, 14 - 16, 20, and 24 - 29 when discussing the rejection, it is assumed that "Claims" refers to claims 9, 10, 12, 14 - 16, 20, and 24 - 29. This rejection is respectfully traversed.

As stated above, claim 9 describes a soldering method which includes replenishing a solder bath with a replenishment solder alloy having a higher concentration of an oxidation suppressing element than does the initial composition of the solder bath. The middle of page 4 of the Official Action acknowledges that such a method is not disclosed by the description on pages 1 - 4 of the specification. However, the Official Action argues that using a replenishment solder alloy containing a higher concentration of an oxidation suppressing element is merely combining two steps which were known in the art (a step of replenishing a solder bath with a replenishment solder alloy having the same composition as the initial composition of a solder bath, and a step of supplying a solder bath with a mother alloy containing a high concentration of an oxidation suppressing element), and that a person skilled in the art would have been

motivated to combine these two steps into one step "in order to save time, reduce inventory, and to simplify process".

The argument made in the Official Action is erroneous for several reasons. Firstly, replenishing a solder bath with a replenishment solder alloy having a higher concentration of an oxidation suppressing element than the initial composition of a solder bath is not the equivalent of simply combining two steps which are performed in the art. Merely combining two known steps would be to simultaneously add a replenishment solder alloy having the same composition as the initial composition of the solder bath together with a mother alloy having a concentration of an oxidation suppressing element. What the method of claim 9 does is to entirely eliminate the need for a mother alloy containing a high concentration of an oxidation suppressing element.

Secondly, the idea of using a replenishment solder alloy having a different composition from the initial composition of a solder bath runs contrary to a number of commonly held views concerning soldering in a soldering bath. Before the development of solder compositions deliberately containing an oxidation suppressing element such as P, an oxidation suppressing element was viewed not as a desired component of a soldered joint but merely as an additive to a solder bath for improving soldering operations. It was thought that simply adding an oxidation suppressing element to a solder bath from time to time was sufficient for the oxidation suppressing element to achieve its

purpose, and it was a basic tenet of soldering in a soldering bath that a replenishment solder should be the same as the solder used to initially prepare the solder bath. Far from it being easier to incorporate an oxidation suppressing element into replenishment solder, it was thought easier to use a replenishment solder which did not contain an oxidation suppressing element and then to periodically add a mother alloy having a high concentration of an oxidation suppressing element to a solder bath as necessary. In this manner, the same replenishment solder alloy could be used under all operating conditions, and it was not necessary to have different types of replenishment solder alloy for different soldering conditions.

When the state of the art developed and the benefits of positively including an oxidation suppressing element in a solder alloy began to be discovered, it was thought the oxidation suppressing element present in a solder alloy was sufficient to provide the effects previously achieved by adding a mother alloy containing an oxidation suppressing element to a solder bath and that there was no need to supplement the oxidation suppressing element contained in the solder. There was no recognition in the art that an oxidation suppressing element in a solder alloy is consumed in a solder bath faster than the solder alloy itself is consumed.

Accordingly, both before and after oxidation suppressing elements began to be positively incorporated into solder alloys, no advantage could be seen by those skilled in the art in

employing a replenishment solder alloy having a higher concentration of an oxidation suppressing element than does the initial composition of the solder bath. With there being no apparent advantage in doing so, a person skilled in the art could not have been motivated to do so. Therefore, the reasons given in the Official Action with respect to claim 9 for modifying the methods described on pages 1 - 4 of the specification are not reasonable, and as such, the rejection of claim 9 does not set forth a *prima facie* case of obviousness. Claims 9 and claims 10, 12, and 16 which depend from it are therefore allowable. As mentioned above, claims 14, 15, and 20 have been cancelled as unnecessary, so the rejections of these claims is moot.

Regarding claim 24, page 6 of the Official Action states that this claim is obvious from the description on page 4, lines 1 - 11 of the specification. Firstly, this description does not constitute prior art as to the Applicants but merely sets forth observations as to what would take place if a solder bath of a P-containing alloy were replenished with the same P-containing alloy. As stated on page 5 of the application, it was the present inventors who first noticed that the rate of decrease of the amount of an oxidation suppressing element such as P in a solder bath due to sacrificial oxidation of P is large compared to the rate of decrease of the amount of solder in the solder bath. This knowledge was not part of the prior art. Rather, in the past, it was thought that when employing a solder bath

containing an oxidation suppressing element such as P, the same alloy could be used for replenishment as was used to initially prepare the solder bath. Therefore, in the past, it would not have occurred to a person performing wave soldering with a solder containing an oxidation suppressing element that there was any need to modify the content of a replenishment solder alloy compared to the initial composition of solder in a solder bath.

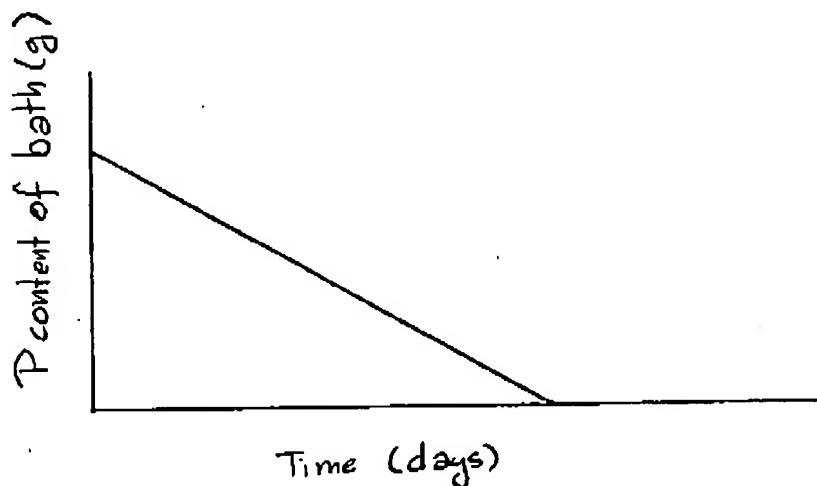
Secondly, amended claim 24 describes a method which avoids the problems of methods used in the past to control the content of an oxidation suppressing element in a solder bath. Amended claim 24 describes a soldering method including a first soldering operation in which soldering is performed using a first replenishment solder alloy having the same composition as the initial composition of the solder bath. This is followed by a second soldering operation which uses a second replenishment solder alloy having a concentration of an oxidation suppressing element which is such that the rate of supply of the oxidation suppressing element in the second replenishment solder alloy to the solder bath in the second soldering operation is greater than or equal to the average rate of decrease of the oxidation suppressing element in the solder bath during the first soldering operation. The second soldering operation begins at the end of the first soldering operation, when the concentration of the oxidation suppressing element is at a level (a "second concentration") resulting from soldering operation over a plurality of days. In other words, the method of amended claim

24 omits the addition of a mother alloy having a high content of an oxidation suppressing element in order to restore the content of the oxidation suppressing element in the bath before starting the second soldering operation. Amended claim 24 is supported by the examples on pages 14 - 17 of the application as filed, in which a second soldering operation follows a first soldering operation without the addition of a mother alloy to a solder bath between the first and second soldering operations. The reason why the step of adding a mother alloy having a high concentration of an oxidation suppressing element to a solder bath is possible will be explained below.

The present inventors noticed that when soldering is performed using a solder bath of a solder which contains an oxidation suppressing element while replenishing the solder bath with a replenishment solder alloy having the same composition as the initial composition of the solder bath, the level (the content) of the oxidation suppressing element in the solder bath drops over time. Given long enough, the level of the oxidation suppressing element will eventually fall to zero.

It was originally assumed that if the soldering conditions in a solder bath (such as the bath volume, the height of a solder wave, the rate at which articles to be soldered are passed through the solder bath, etc.) are constant, the rate of decrease of an oxidation suppressing element (g/day) in the solder bath will be constant. In other words, it was thought that during soldering under constant conditions, the content of the oxidation

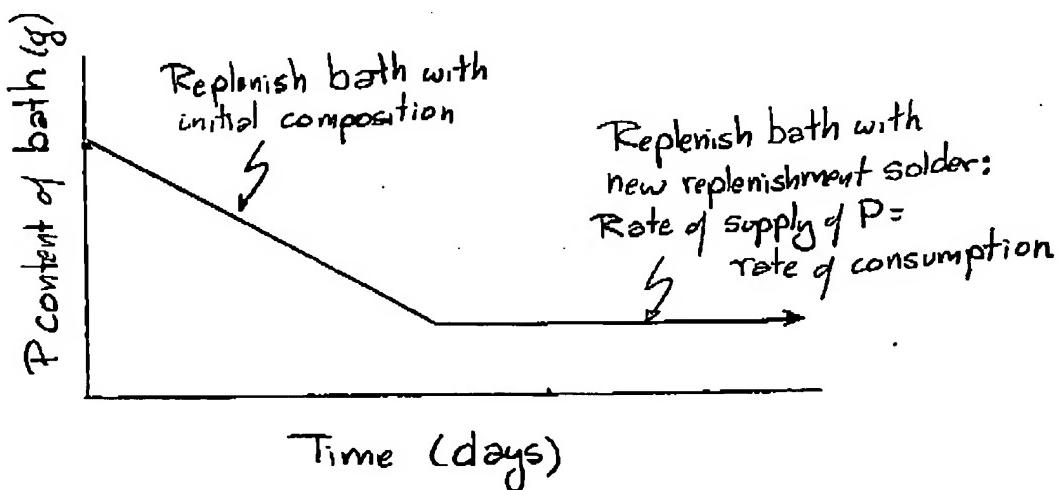
suppressing element in the bath would linearly decrease, as shown in the following graph, which uses P as an example of an oxidation suppressing element.



If a user of a solder bath can determine the rate of decrease of P during the soldering operation, i.e., the slope of the above curve, the user can select a replenishment solder alloy which can supply P to the bath at the same rate that P is being consumed in the bath. If this replenishment solder alloy is supplied to the solder bath, it should be possible to maintain the content of P in the solder bath constant.

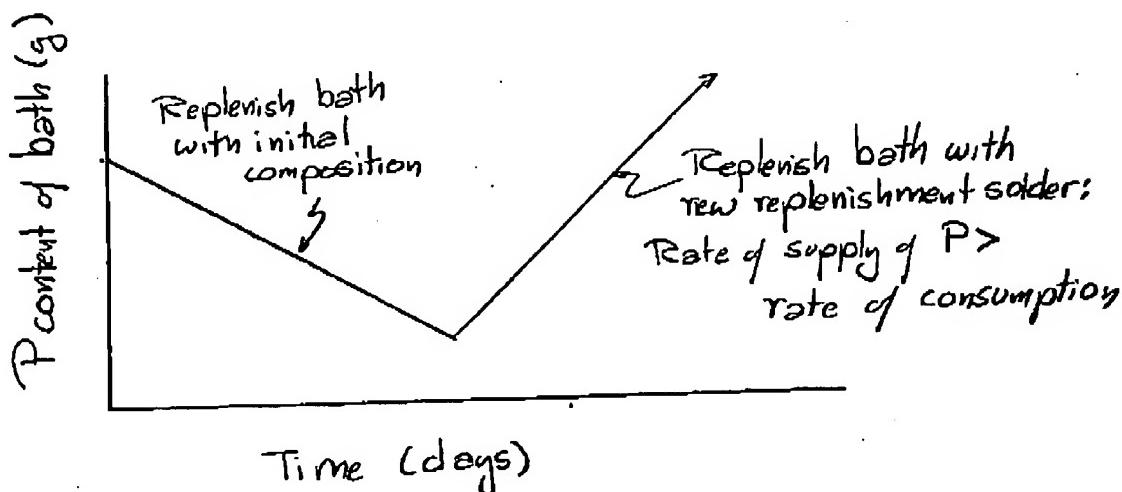
However, due to the margin of error in measurement of the concentration of a component of a solder bath, it is difficult to accurately determine the rate of decrease of an oxidation suppressing element such as P in a solder bath with accuracy over a short period of operation of a solder bath, since the change in the level of P during that period  $\Delta P$  will be comparable to the

measurement error. In order to make an accurate determination of the rate of decrease of P, it is desirable to measure the P content of a solder bath over an extended period spanning a plurality of days (such as about 1 to 2 weeks) so as to obtain a significant decrease  $\Delta P$  in the P content. Due to the large change in the P content over the extended period, the P content in the bath may fall to an undesirably low level. At the end of the extended period of measurement, if a new replenishment solder alloy is used which supplies P to the bath at the same rate as P was consumed in the solder bath during the measurement period, although the level of P in the solder bath will be stabilized, it will remain at the low level existing at the end of the extended period of measurement, as shown in the following graph.

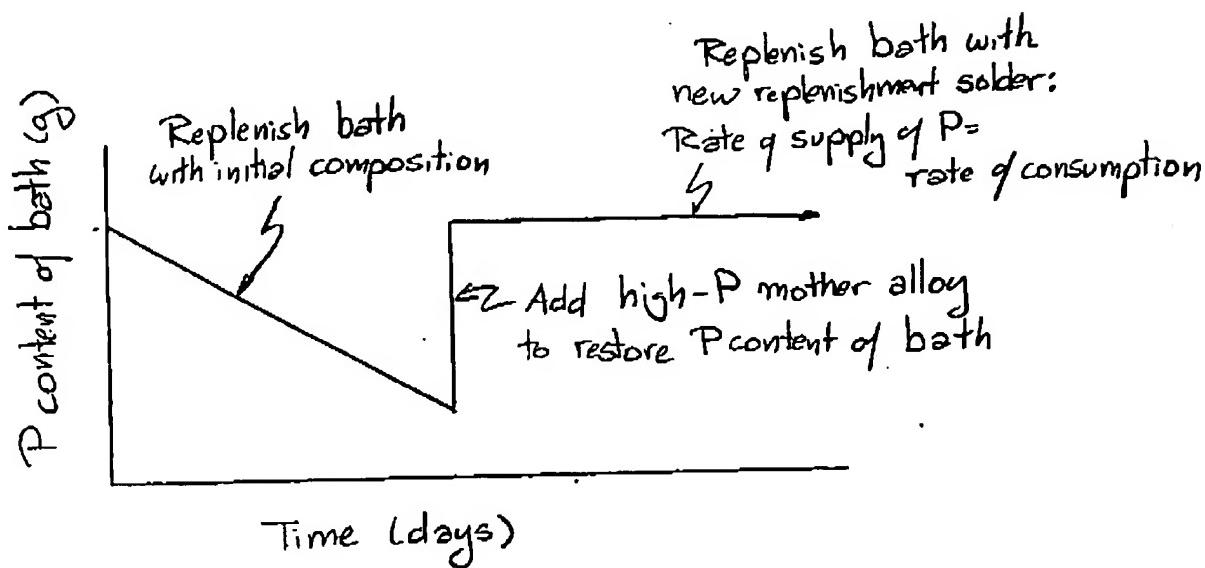


If a replenishment solder is chosen which has a P content such that P is supplied to the solder bath by the replenishment

solder alloy at a rate which is higher than the rate of decrease of P in the solder bath during the measurement period, the replenishment solder alloy will cause the P content of the bath to monotonically increase without stabilizing, as shown by the following graph.



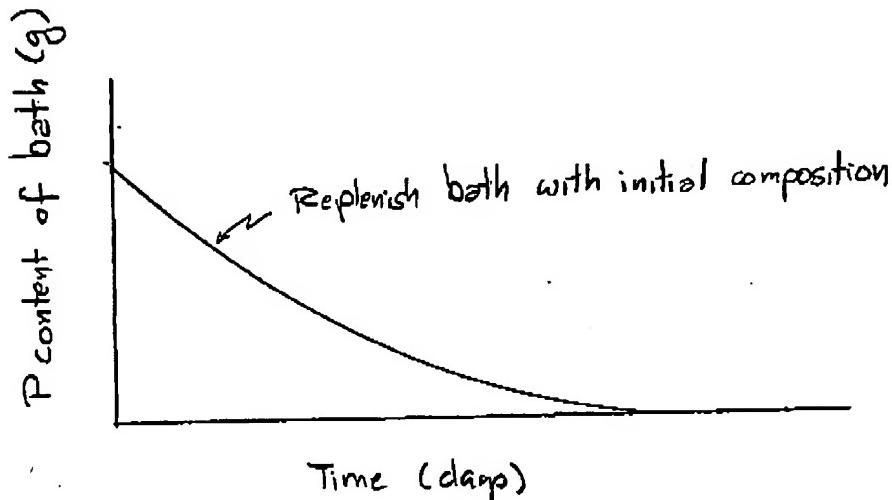
Therefore, under the assumption that the rate of consumption of P in the solder bath is constant, the only practical way to restore the P content in the solder bath to a suitable level and then stabilize the P content at that level is to first add a mother alloy containing a high concentration of P to the solder bath to increase the level of P, and then replenish the solder bath with a replenishment solder alloy which supplies P to the bath at the same rate as P is consumed in the bath, as shown by the following graph.



Although such a method can stabilize the P content in a solder bath, since it requires the addition of a mother alloy, it has the problems described on page 4 of the application that is necessary to perform troublesome operations such as weighing the amount of mother alloy to be charged, charging the mother alloy into a solder bath and stirring for a fixed length of time, and checking the concentration in the solder bath after adjustment.

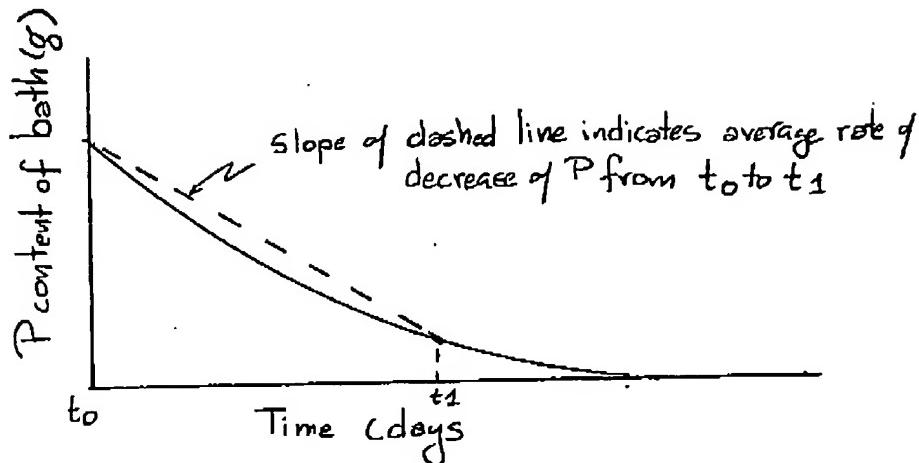
Upon further research, the present inventors discovered that contrary to their initial belief concerning the behavior of P or other oxidation suppressing element in a solder bath, the rate of decrease of an oxidation suppressing element in a solder bath is not constant under constant soldering conditions. Instead, the rate of decrease of an oxidation suppressing element at a given moment depends upon the concentration of the oxidation suppressing element in the bath at that moment. As a result, the content of P or other oxidation suppressing element in a solder

bath changes nonlinearly over time. The following graph schematically illustrates (in an exaggerated manner, since the shape of a curve connecting data points is not so evidently nonlinear) the change in the content of P in a solder bath over time under constant operating conditions when the solder bath is being replenished by a solder alloy having the same content of P as the initial composition of the solder bath.



It is difficult to accurately determine the instantaneous rate of decrease of P on this curve, i.e., the slope of the curve at a particular point. However, if the P content in the solder bath is measured over an extended period of a plurality of days, the average rate of decrease over the period of measurement can be accurately determined. The average rate of decrease of P between times  $t_0$  (at the start of the extended period) and  $t_1$  (at the end of the extended period of soldering operation) is indicated by the slope of the dashed line in the following

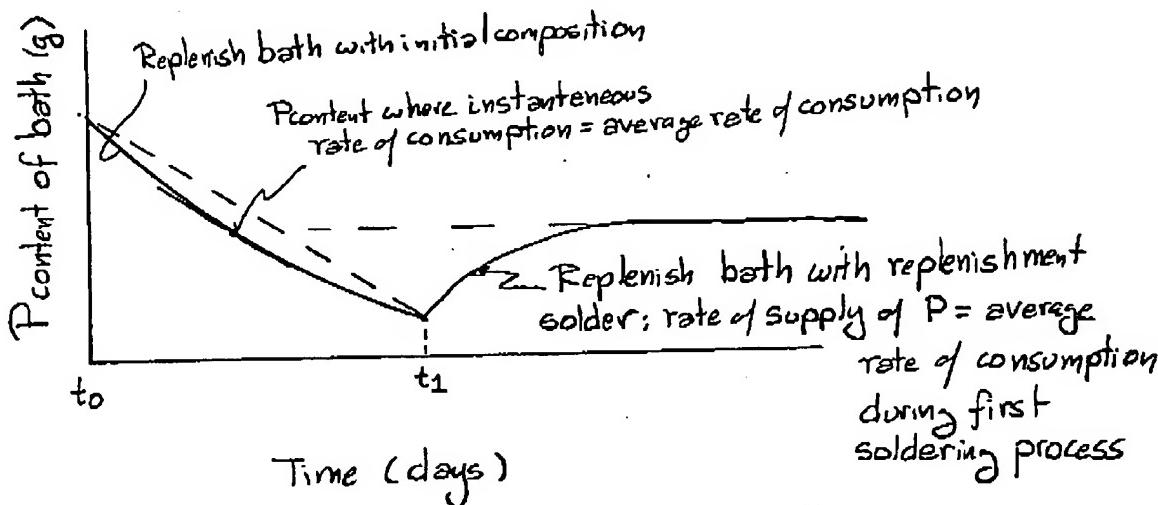
figure.



It can be seen from this graph that the average rate of decrease of P is the same as the instantaneous rate of decrease at some point in time between the start of soldering  $t_0$  and the end  $t_1$  of the extended period over which the P content was measured. The average rate of decrease is less than the initial rate of decrease at the start of soldering at time  $t_0$ , but it is larger than the rate of decrease of P at the end of the extended period of measurement at time  $t_1$ .

At the end of the extended period of measurement, if the solder bath is replenished with a replenishment solder alloy which supplies P to the solder bath at a rate which is greater than or equal to the average rate of decrease of P during the measurement period indicated by the dashed line, since the average rate of decrease of P during the measurement period is larger than the instantaneous rate of decrease of the bath at

time  $t_1$ , the level of P in the solder bath will gradually increase from the level at time  $t_1$  to a level at which the rate of supply of P to the bath by the replenishment solder alloy just equals the rate at which P is being consumed at that level of P. This phenomenon is shown by the following graph.



The examples in the present application, and particularly Example 4 (the results of which are shown in Figure 1 of the application) illustrate the results of actual use of this method. In each example, the P content of a solder bath can be stabilized at a suitable level by using a replenishment solder alloy which supplies P to the solder bath at a rate which is greater than or equal to the rate at which P was consumed during a first soldering operation when the solder bath was replenished with a replenishment solder alloy having the same P content as the initial composition of the solder bath. As shown by the examples, there is no need to supply a mother alloy having a high

content of P to the solder bath after determining the rate of decrease of P in a first soldering operation. Eliminating the need to supply a mother alloy to the solder bath can greatly simplify soldering operations, since it becomes unnecessary to perform the above-described troublesome steps such as weighing the amount of mother alloy to be charged, etc.

The method described by claim 24 includes not only replenishing a solder bath with a second replenishment solder alloy having a higher concentration (the third concentration) of an oxidation suppressing element than the concentration of that element in the initial composition of the solder bath (the first concentration), but it includes starting a second soldering operation using the second replenishment solder alloy from the concentration of the oxidation suppressing element existing at the end of the first soldering operation (the second concentration) without adding a mother alloy to the solder bath to restore the concentration of the oxidation suppressing element between the first and second soldering operations. As set forth above with respect to claim 9, the concept of replenishing a solder bath with a replenishment solder alloy having a higher concentration of an oxidation suppressing element than the concentration of that element in the initial composition of the solder bath is not disclosed by or obvious from the description on pages 1 - 4 of the present application.

Moreover, even if it were to occur to a person to use a replenishment solder alloy having a higher concentration of an

oxidation suppressing element than the concentration of that element in the initial composition of a solder bath, he would think it necessary, as discussed above, to first raise the concentration of the oxidation suppressing element in the solder bath from its depleted level before beginning soldering operation using the replenishment solder alloy having a higher concentration of the oxidation suppressing element. This is contrary to the method set forth in claim 24.

As the art cited by the Official Action does not contain any teachings that could lead a person skilled in the art to carry out a method having all the steps set forth in claim 24, the art cannot render claim 24 obvious. Claim 24 and claims 27 and 28 which depend from claim 24 are therefore allowable. Claims 25 and 26 have been cancelled as unnecessary, so their rejection is now moot. At the same time, both of claim 27 and 28 have been amended to change "second concentration" to "third concentration" so as to agree with the wording of amended claim 24.

On page 8 of the Official Action, claims 11 and 17 - 19 were rejected under 35 USC 103(a) as unpatentable over the description on pages 1 - 4 of the specification in view of Steen et al (WO 01/03878, referred to below as Steen) and Kim (KR 2001-107354). This rejection is respectfully traversed.

Claims 18 and 19 have been cancelled as unnecessary. Claim 17, which has been amended to delete unnecessary limitations, states that in the method of claim 9, the replenishment solder

alloy contains 60 - 100 ppm of P. With respect to claim 17, both Steen and Kim were apparently relied upon as teaching a solder alloy having a composition which overlaps the composition set forth in claim 17 and which, in particular, may contain 60 - 100 ppm of P. Specifically, Steen discloses a lead-free solder for use in a wave solder bath which contains up to 0.01% and preferably 0.001 - 0.004% of P, and Kim discloses a lead-free solder composition containing 0.0001 - 3.0 wt % of P.

However, claim 17 is not a product claim, so the fact that Steen and Kim teach solder alloys having compositions which overlap the composition of the solder alloy employed in claim 17 not does automatically render this claim obvious. Claim 17, which is a method claim, depends from claim 9, which includes replenishing a solder bath with a replenishment solder alloy having a higher concentration of an oxidation suppressing element than does the initial composition of the solder bath. As set forth above with respect to claim 9, the description on pages 1 - 4 of the present application contains nothing that could lead a person skilled in the art to replenish a solder bath with such a solder alloy. Steen and Kim mention nothing about the idea of replenishment solder alloys. In fact, it is not even clear whether the solder alloy of Kim is intended for use in a solder bath. According to the abstract of Kim, "The phosphorus, in melted condition, rises to the surface of liquid solder composition to form a thin layer, whereby blocking contact between liquid solder composition and air." The language "liquid

solder composition" might refer not to a solder bath at all but to a molten solder powder, a molten solder wire, a molten solder pellet, or the like.

Thus, Steen and Kim contain no teachings that make up for the shortcomings of the description on pages 1 - 4 of the present application, so the references are lacking in teachings that could be reasonably combined to result in a method having all the features set forth in claim 9 and included in claim 17 by its dependency therefrom. The rejection of claim 17 is therefore unreasonable, and this claim is thus allowable.

Dependent claim 11 states that in the method of claim 9, the replenishment solder alloy has the same composition as the initial composition of the solder bath except for the oxidation suppressing element and copper. In claim 11, the words "initial composition of the" have been added before "solder bath" to clarify the point of reference for the solder composition, just as in claim 9. Amended claim 11 is supported by pages 9 and 10 of the application as filed.

It is not clear why either Steen or Kim was relied upon with respect to claim 11, since neither of these references teaches anything about a replenishment solder alloy, and particularly the idea of a replenishment solder alloy having a different content of Cu from the initial composition of a solder bath. The description on pages 1 - 4 of the present application likewise discloses nothing about the Cu concentration of a replenishment

solder alloy being different from that in the initial composition of a solder bath. Therefore, as the references fail to teach or suggest the concept of a replenishment solder alloy having a different content of Cu from the initial composition of a solder bath, they cannot be combined in a manner resulting in a method having all the features of claim 11 and cannot render this claim obvious.

New claims 30 - 33 describe additional features of the present invention. Claims 30 - 32 are allowable as depending from claim 24. New claim 33 describes a simple method of performing soldering which is described on page 12, lines 22 - 27 of the application as filed. In this simple method, in contrast to the method described by claim 24, it is not necessary to measure the rate of decrease of an oxidation suppressing element in a solder bath. Instead, the concentration of an oxidation suppressing element in the solder bath is determined by simply multiplying the initial concentration of the oxidation suppressing element in the solder bath by 2 - 6 to obtain a concentration in the range of 60 - 100 ppm. The solder bath is then replenished from the start of operation using a replenishment solder alloy having the thus calculated concentration of the oxidation suppressing element. There is no suggestion in the description on pages 1 - 4 of the present application or in the other references cited in the Official Action of such a simple method of selecting a replenishment

solder alloy. Claim 33 is therefore allowable.

In light of the foregoing remarks, it is believed that the present application is in condition for allowance. Favorable consideration is respectfully requested.

Respectfully submitted,



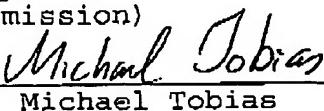
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